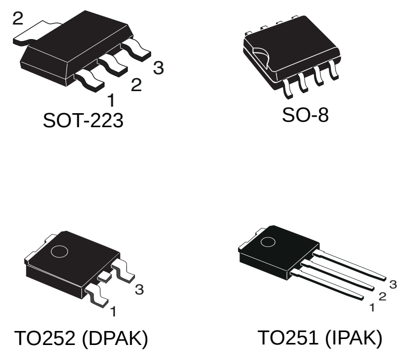
VNN3NV04, VNS3NV04
VND3NV04, VND3NV04-1

OMNIFET II
fully autoprotected Power MOSFET

Features

Type	$R_{DS(on)}$	I_{lim}	V_{clamp}
VNN3NV04 VNS3NV04 VND3NV04 VND3NV04-1	120 mΩ	3.5 A	40 V

- Linear current limitation
- Thermal shutdown
- Short circuit protection
- Integrated clamp
- Low current drawn from input pin
- Diagnostic feedback through input pin
- ESD protection
- Direct access to the gate of the Power MOSFET (analog driving)
- Compatible with standard Power MOSFET in compliance with the 2002/95/EC European Directive



Description

The VNN3NV04, VNS3NV04, VND3NV04 VND3NV04-1, are monolithic devices designed in STMicroelectronics™ VIPower™ M0-3 Technology, intended for replacement of standard Power MOSFETs from DC up to 50 kHz applications. Built in thermal shutdown, linear current limitation and overvoltage clamp protect the chip in harsh environments.

Fault feedback can be detected by monitoring the voltage at the input pin.

Table 1. Device summary

Package	Order codes			
	Tube	Tube (lead-free)	Tape and reel	Tape and reel (lead-free)
SOT-223	VNN3NV04	-	VNN3NV0413TR	-
SO-8	VNS3NV04	-	VNS3NV0413TR	-
TO-252	VND3NV04	VND3NV04-E	VND3NV0413TR	VND3NV04TR-E
TO-251	VND3NV04-1	VND3NV04-1-E	-	-

Contents

List of tables

List of figures

1 Block diagram and pin description

Figure 1. Block diagram

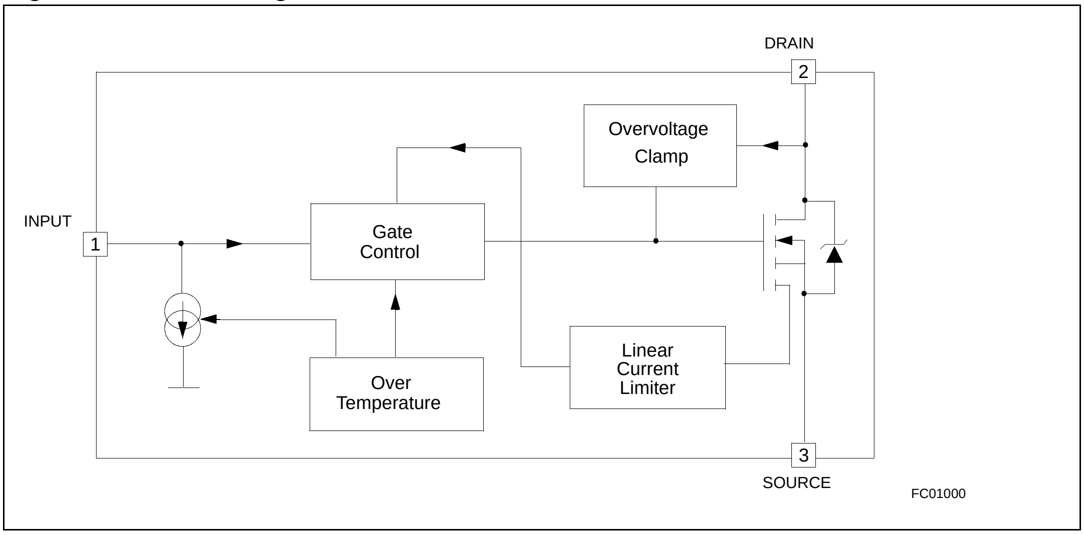
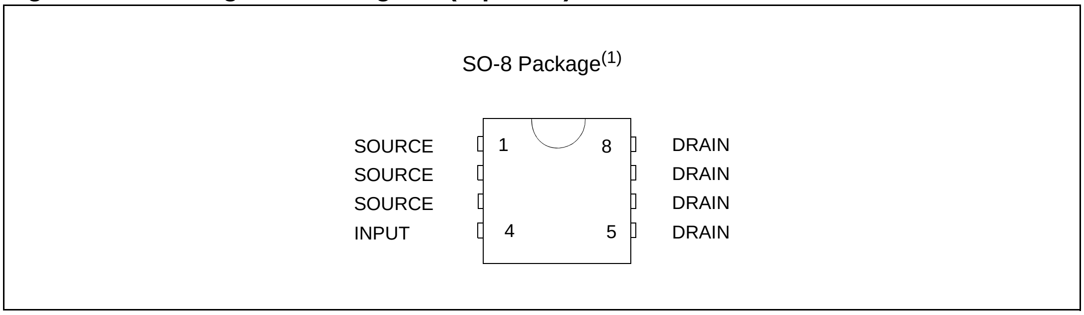


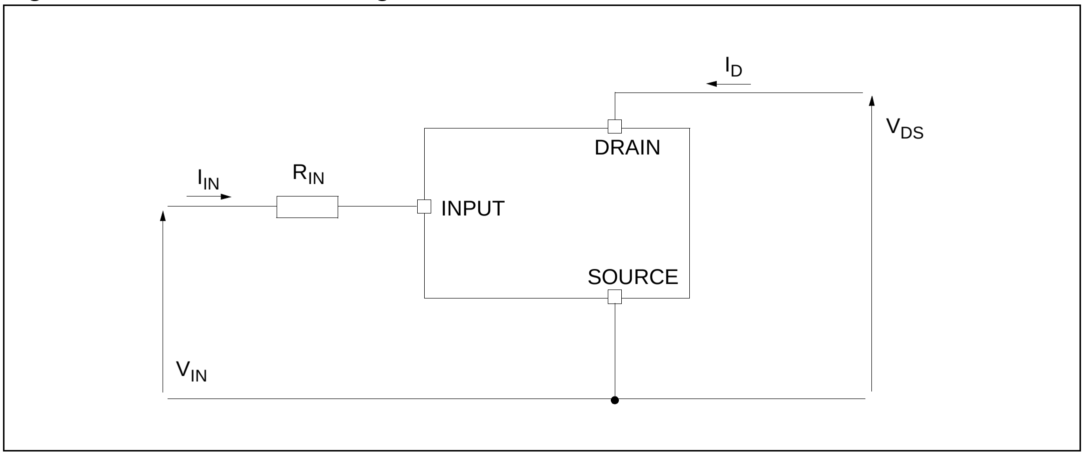
Figure 2. Configuration diagram (top view)



1. For the pins configuration related to SOT-223, DPAK, IPAK see outlines at page 1.

2 Electrical specifications

Figure 3. Current and voltage conventions



2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value			Unit
		SOT-223	SO-8	DPAK/IPAK	
V_{DS}	Drain-source voltage (V_{IN}=0 V)	Internally clamped			V
V_{IN}	Input voltage	Internally clamped			V
I_{IN}	Input current	+/-20			mA
$R_{IN\ MIN}$	Minimum input series impedance	220			Ω
I_D	Drain current	Internally limited			A
I_R	Reverse DC output current	-5.5			A
V_{ESD1}	Electrostatic discharge (R=1.5 KΩ, C=100 pF)	4000			V
V_{ESD2}	Electrostatic discharge on output pin only (R=330 Ω, C=150 pF)	16500			V
P_{tot}	Total dissipation at T_c=25 °C	7	8.3	35	W
T_j	Operating junction temperature	Internally limited			°C
T_c	Case operating temperature	Internally limited			°C
T_{stg}	Storage temperature	-55 to 150			°C

2.2 Thermal data

Table 3. Thermal data

Symbol	Parameter	Value				Unit
		SOT-223	SO-8	DPAK	IPAK	
$R_{thj\text{-}case}$	Thermal resistance junction-case max	18		3.5	3.5	°C/W
$R_{thj\text{-}lead}$	Thermal resistance junction-lead max		15			°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient max	70(1)	65(1)	54(1)	100	°C/W

1. When mounted on a standard single-sided FR4 board with 50 mm^2 of Cu (at least 35 mm thick) connected to all DRAIN pins.

2.3 Electrical characteristics

-40 °C < T_j < 150 °C, unless otherwise specified.

Table 4. Electrical characteristics

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Off						
V_{CLAMP}	Drain-source clamp voltage	V_{IN}=0 V; I_D=1.5 A	40	45	55	V
V_{CLTH}	Drain-source clamp threshold voltage	V_{IN}=0 V; I_D=2 mA	36			V
V_{INTH}	Input threshold voltage	V_{DS}=V_{IN}; I_D=1 mA	0.5		2.5	V
I_{ISS}	Supply current from input pin	V_{DS}=0 V; V_{IN}=5 V		100	150	µA
V_{INCL}	Input-source clamp voltage	I_{IN}=1 mA I_{IN}=-1 mA	6 -1.0	6.8	8 -0.3	V
I_{DSS}	Zero input voltage drain current (V_{IN}=0 V)	V_{DS}=13 V; V_{IN}=0 V; T_j=25 °C V_{DS}=25 V; V_{IN}=0 V			30 75	µA
On						
$R_{DS(on)}$	Static drain-source on resistance	V_{IN}=5 V; I_D=1.5 A; T_j=25 °C V_{IN}=5 V; I_D=1.5 A			120 240	mΩ
Dynamic (T_j=25 °C, unless otherwise specified)						
g_{fs} (1)	Forward transconductance	V_{DD}=13 V; I_D=1.5 A		5.0		S
C_{OSS}	Output capacitance	V_{DS}=13 V; f=1 MHz; V_{IN}=0 V		150		pF
Switching (T_j=25 °C, unless otherwise specified)						

Table 4. Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	V_{DD}=15 V; I_D=1.5 A V_{gen}=5 V; R_{gen}=$R_{IN\ MIN}$=220 Ω (see figure *Figure 4.*)		90	300	ns
t_r	Rise time			250	750	ns
$t_{d(off)}$	Turn-off delay time			450	1350	ns
t_f	Fall time			250	750	ns
$t_{d(on)}$	Turn-on delay time	V_{DD}=15 V; I_D=1.5 A V_{gen}=5 V; R_{gen}=2.2 KΩ (see figure *Figure 4.*)		0.45	1.35	µs
t_r	Rise time			2.5	7.5	µs
$t_{d(off)}$	Turn-off delay time			3.3	10.0	µs
t_f	Fall time			2.0	6.0	µs
$(dI/dt)_{on}$	Turn-on current slope	V_{DD}=15 V; I_D=1.5 A V_{gen}=5 V; R_{gen}=$R_{IN\ MIN}$=220 Ω		4.7		A/µs
Q_i	Total input charge	V_{DD}=12 V; I_D=1.5 A; V_{IN}=5 V I_{gen}=2.13 mA (see figure *Figure 7.*)		8.5		nC
Source drain diode (T_j=25 °C, unless otherwise specified)						
V_{SD}(1)	Forward on voltage	I_{SD}=1.5 A; V_{IN}=0 V		0.8		V
t_{rr}	Reverse recovery time	I_{SD}=1.5 A; dI/dt=12 A/µs V_{DD}=30 V; L=200 µH (see test circuit, figure *Figure 5.*)		107		ns
Q_{rr}	Reverse recovery charge			37		µC
I_{RRM}	Reverse recovery current			0.7		A
Protections (-40 °C < T_j < 150 °C, unless otherwise specified)						
I_{lim}	Drain current limit	V_{IN}=5 V; V_{DS}=13 V	3.5	5	7	A
t_{dlim}	Step response current limit	V_{IN}=5 V; V_{DS}=13 V		10		µs
T_{jsh}	Over temperature shutdown		150	175	200	°C
T_{jrs}	Over temperature reset		135			°C
I_{gf}	Fault sink current	V_{IN}=5 V; V_{DS}=13 V; T_j=T_{jsh}	10	15	20	mA
E_{as}	Single pulse avalanche energy	starting T_j=25µ°C; V_{DD}=24 V V_{IN}=5 V R_{gen}=$R_{IN\ MIN}$=220 Ω; L=24 mH (see figures *Figure 6.* & *Figure 8.*)	100			mJ

1. Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

3 Protection features

During normal operation, the input pin is electrically connected to the gate of the internal Power MOSFET through a low impedance path.

The device then behaves like a standard Power MOSFET and can be used as a switch from DC up to 50 kHz. The only difference from the user's standpoint is that a small DC current I_{ISS} (typ. 100µA) flows into the input pin in order to supply the internal circuitry.

The device integrates:

- Overvoltage clamp protection: internally set at 45 V, along with the rugged avalanche characteristics of the Power MOSFET stage give this device unrivalled ruggedness and energy handling capability. This feature is mainly important when driving inductive loads.
- Linear current limiter circuit: limits the drain current I_D to I_{lim} whatever the input pin voltages. When the current limiter is active, the device operates in the linear region, so power dissipation may exceed the capability of the heatsink. Both case and junction temperatures increase, and if this phase lasts long enough, junction temperature may reach the over temperature threshold T_{jsh}.
- Over temperature and short circuit protection: these are based on sensing the chip temperature and are not dependent on the input voltage. The location of the sensing element on the chip in the power stage area ensures fast, accurate detection of the junction temperature. Over temperature cutout occurs in the range 150 to 190 °C, a typical value being 170 °C. The device is automatically restarted when the chip temperature falls of about 15 °C below shutdown temperature.
- Status feedback: in the case of an over temperature fault condition ($T_j > T_{jsh}$), the device tries to sink a diagnostic current I_{gf} through the input pin in order to indicate fault condition. If driven from a low impedance source, this current may be used in order to warn the control circuit of a device shutdown. If the drive impedance is high enough so that the input pin driver is not able to supply the current I_{gf}, the input pin will fall to 0 V. This will not however affect the device operation: no requirement is put on the current capability of the input pin driver except to be able to supply the normal operation drive current I_{ISS}.

Additional features of this device are ESD protection according to the Human Body model and the ability to be driven from a TTL logic circuit.

Figure 4. Switching time test circuit for resistive load

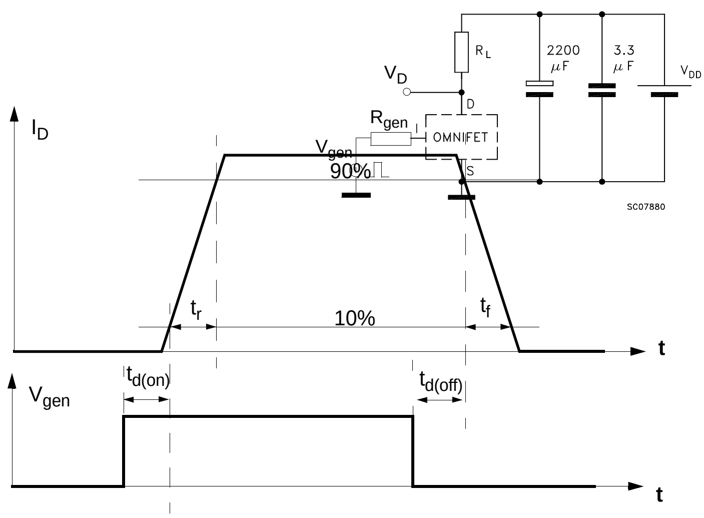


Figure 5. Test circuit for diode recovery times

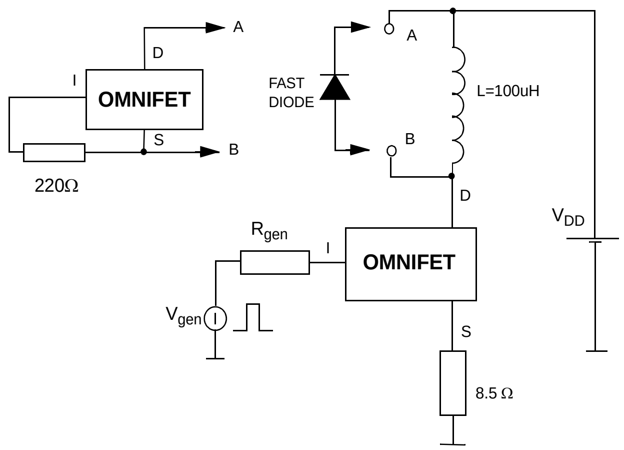


Figure 6. Unclamped inductive load test circuits

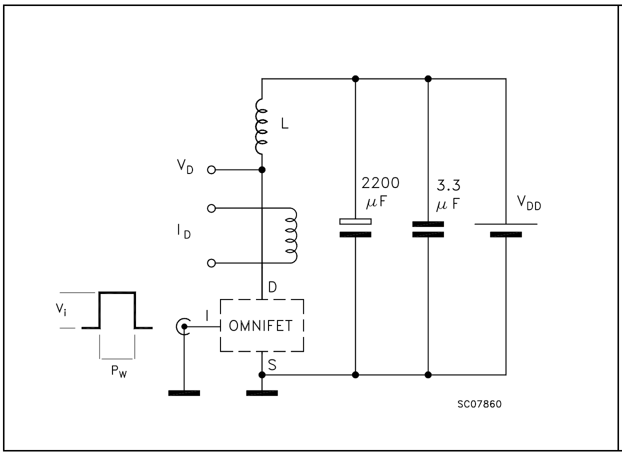


Figure 7. Input charge test circuit

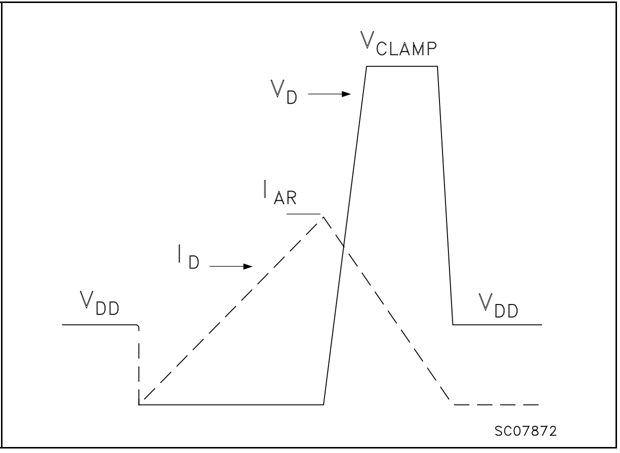
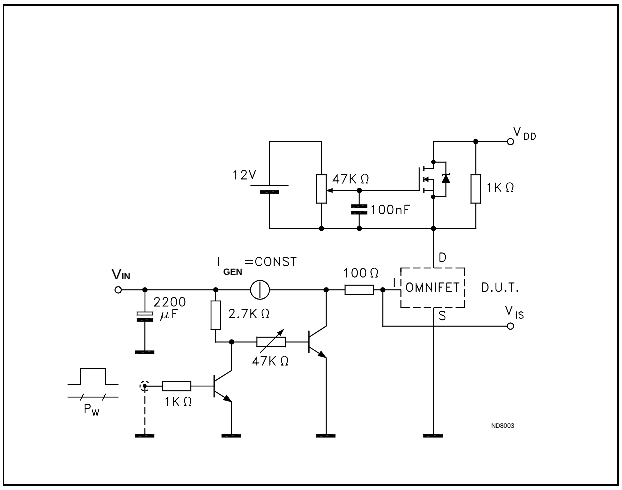


Figure 8. Unclamped inductive waveforms



3.1 Electrical characteristics curves

Figure 9. Thermal impedance for DPAK/IPAK

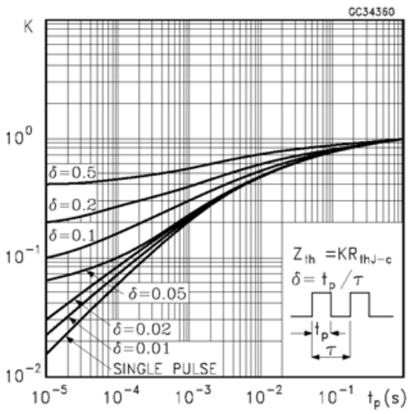


Figure 10. Thermal impedance for SOT-223

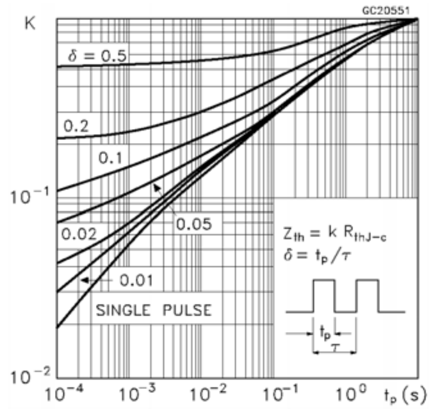


Figure 11. Derating curve

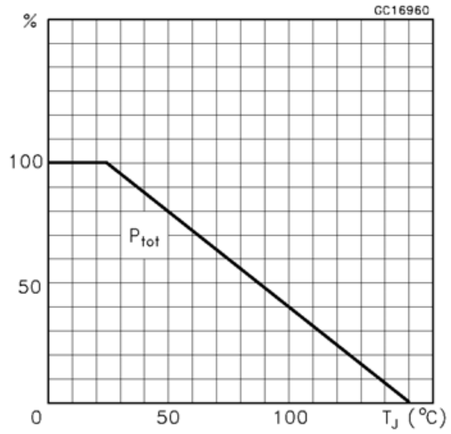


Figure 12. Transconductance

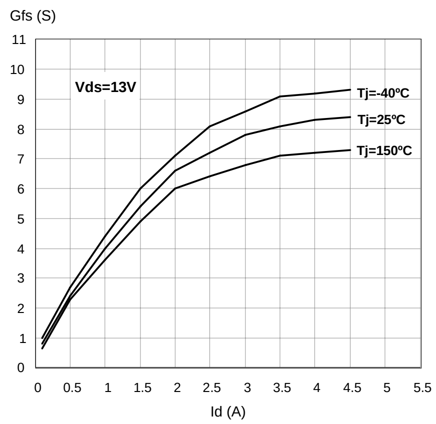


Figure 13. Static drain-source on resistance vs input voltage (part 1/2)

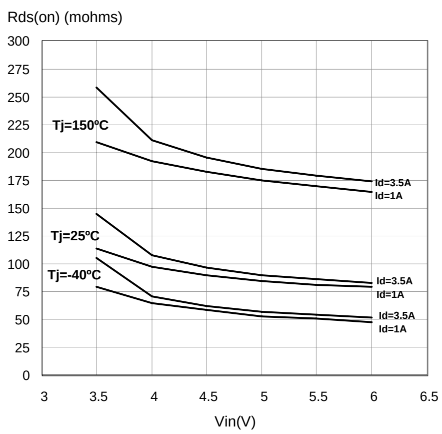


Figure 14. Static drain-source on resistance vs input voltage (part 2/2)

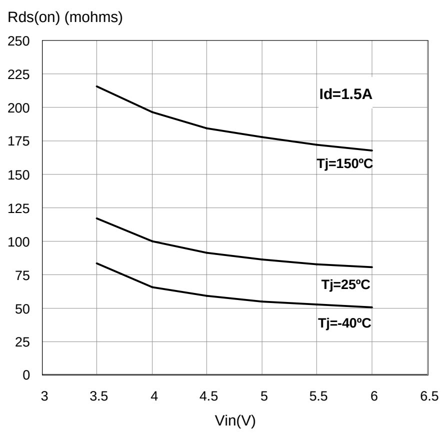


Figure 15. Source-drain diode forward characteristics

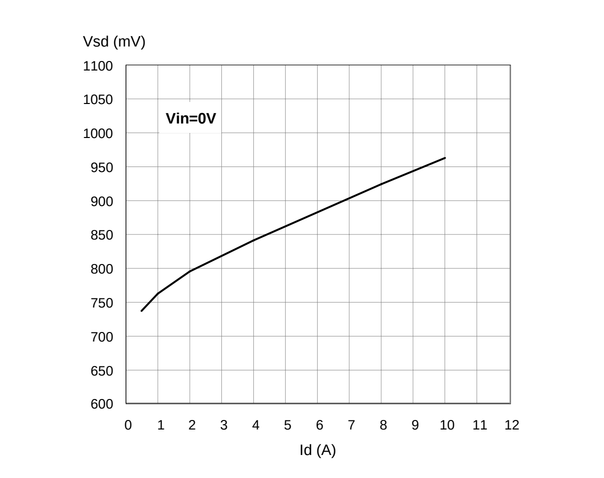


Figure 16. Static drain source on resistance

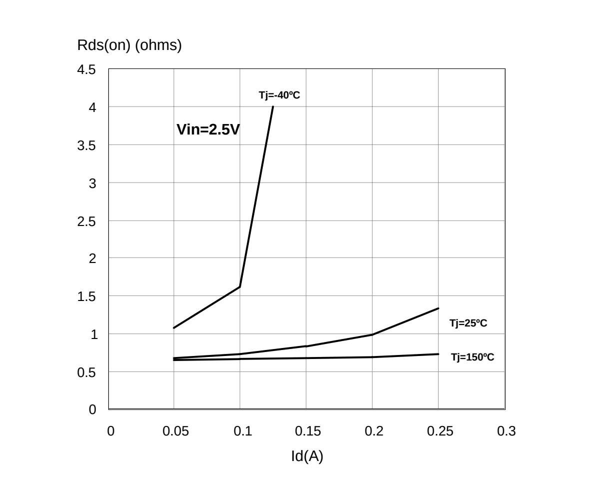


Figure 17. Turn-on current slope (part 1/2)

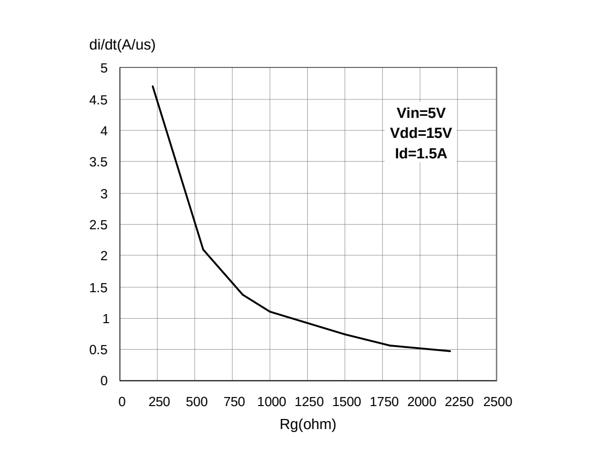


Figure 18. Turn-on current slope (part 2/2)

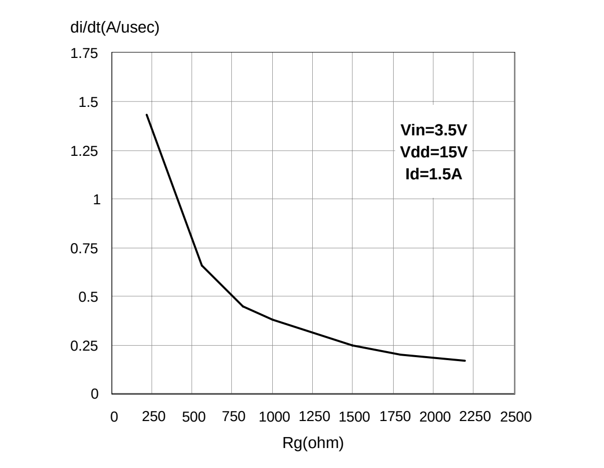


Figure 19. Transfer characteristics

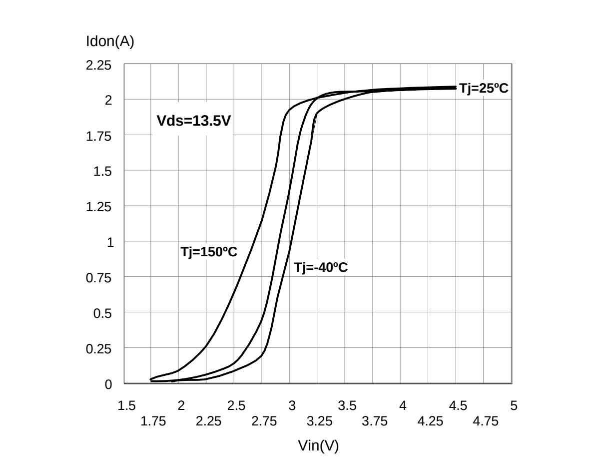


Figure 20. Static drain-source on resistance vs Id

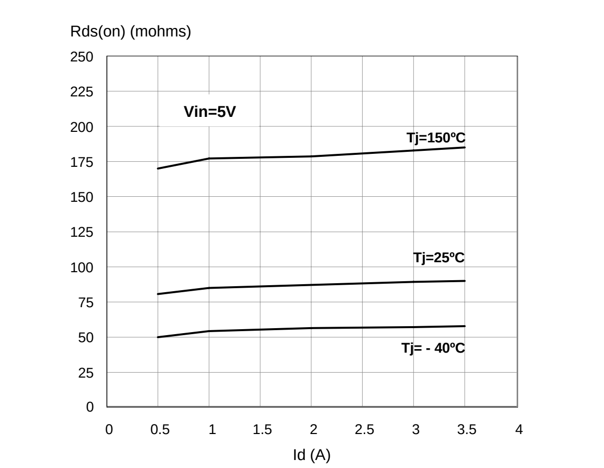


Figure 21. Input voltage vs input charge

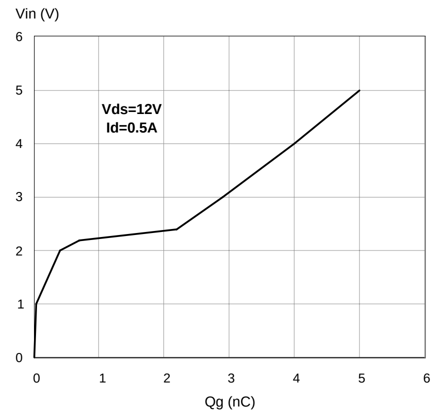


Figure 22. Turn-off drain source voltage slope (part 1/2)

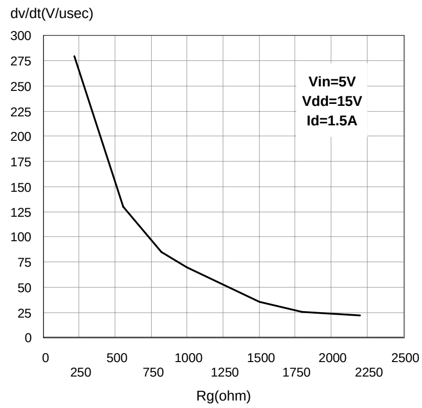


Figure 23. Turn-off drain source voltage slope (part 2/2)

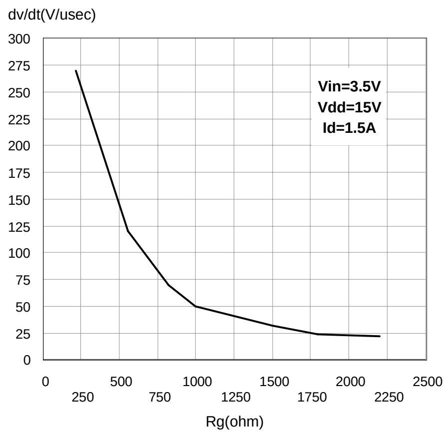


Figure 24. Capacitance variations

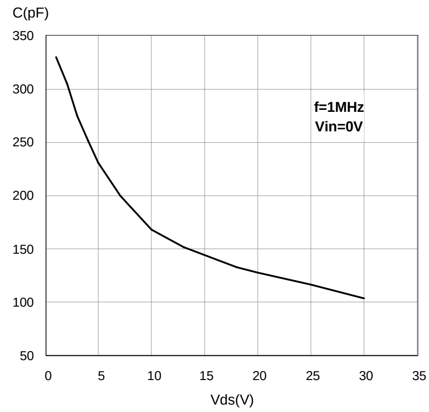


Figure 25. Output characteristics

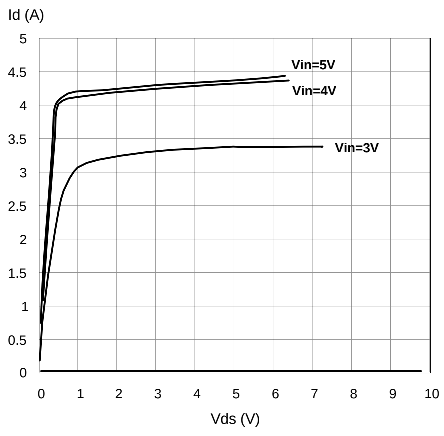


Figure 26. Normalized on resistance vs temperature

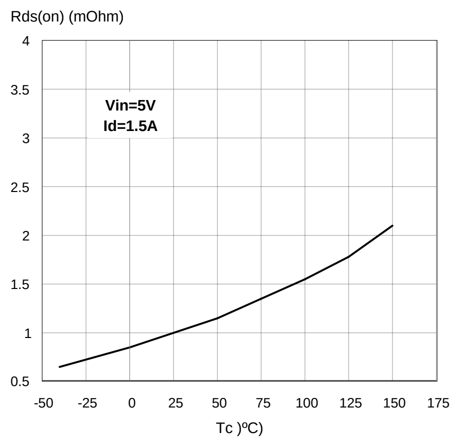


Figure 27. Switching time resistive load (part 1/2)

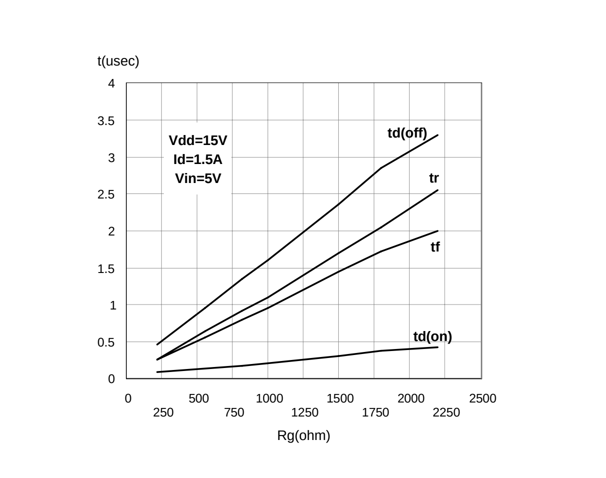


Figure 28. Switching time resistive load (part 2/2)

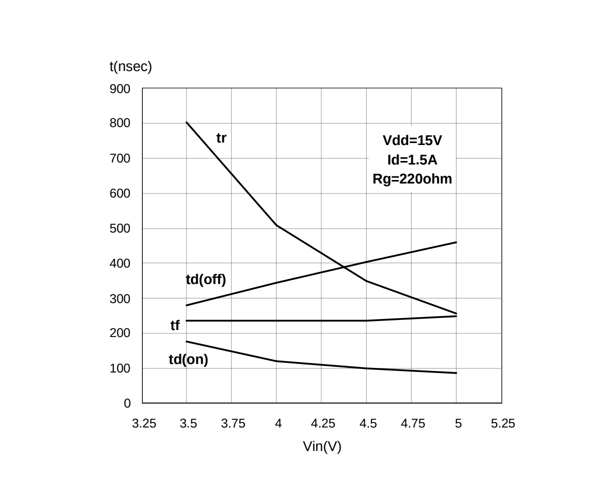


Figure 29. Normalized input threshold voltage vs temperature

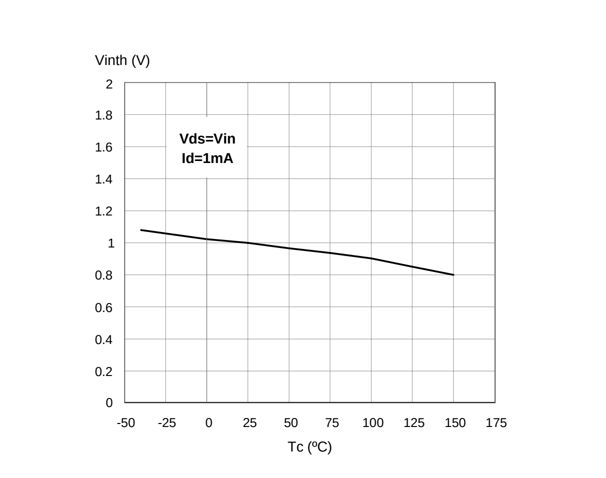


Figure 30. Normalized current limit vs junction temperature

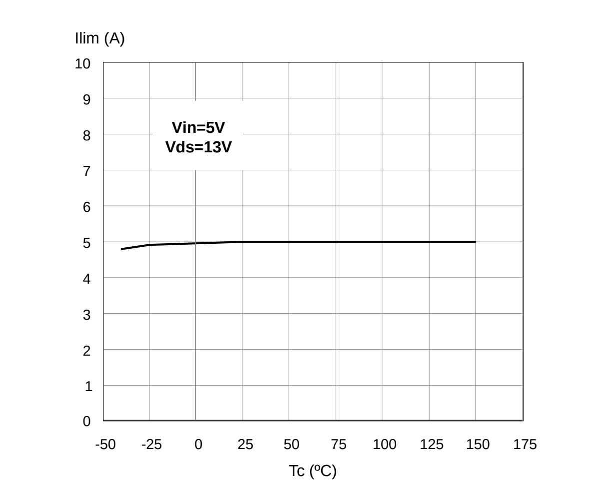
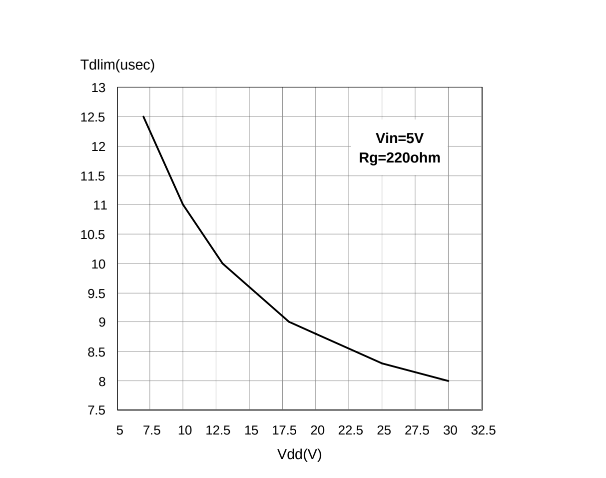


Figure 31. Step response current limit



4 Package and packing information

4.1 ECOPACK®

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*.

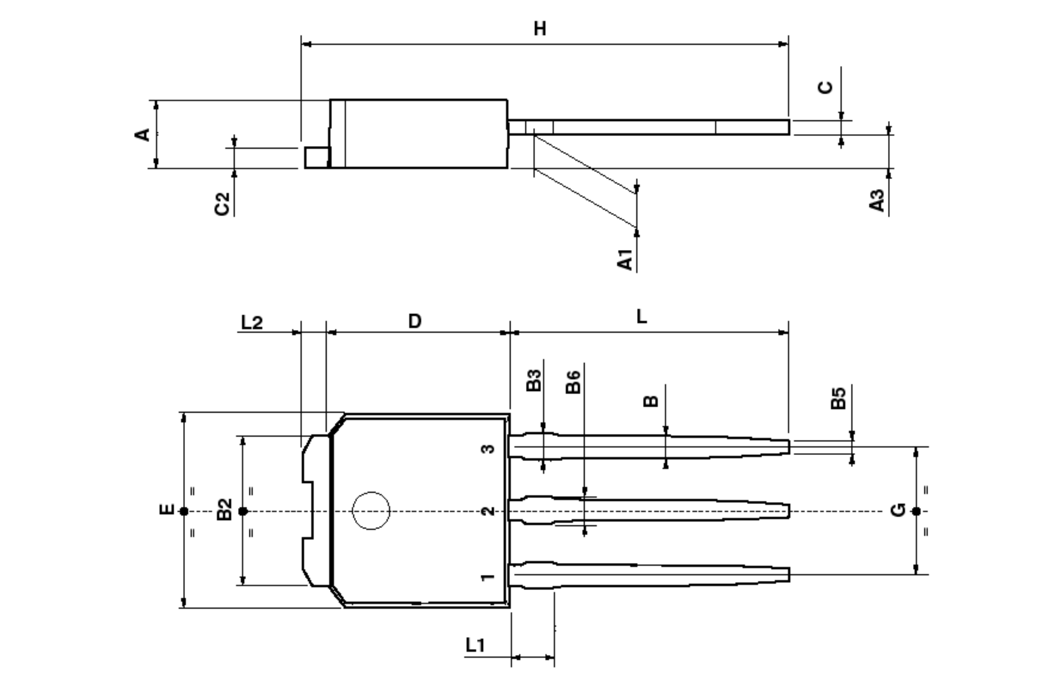
ECOPACK® is an ST trademark.

4.2 TO-251 (IPAK) mechanical data

Table 5. TO-251 (IPAK) mechanical data

Symbol	millimeters		
	Min.	**Typ.**	**Max.**
A	2.2		2.4
A1	0.9		1.1
A3	0.7		1.3
B	0.64		0.9
B2	5.2		5.4
B3			0.85
B5		0.3	
B6			0.95
C	0.45		0.6
C2	0.48		0.6
D	6		6.2
E	6.4		6.6
G	4.4		4.6
H	15.9		16.3
L	9		9.4
L1	0.8		1.2
L2		0.8	1

Figure 32. TO-251 (IPAK) package dimensions



4.3 TO-252 (DPAK) mechanical data

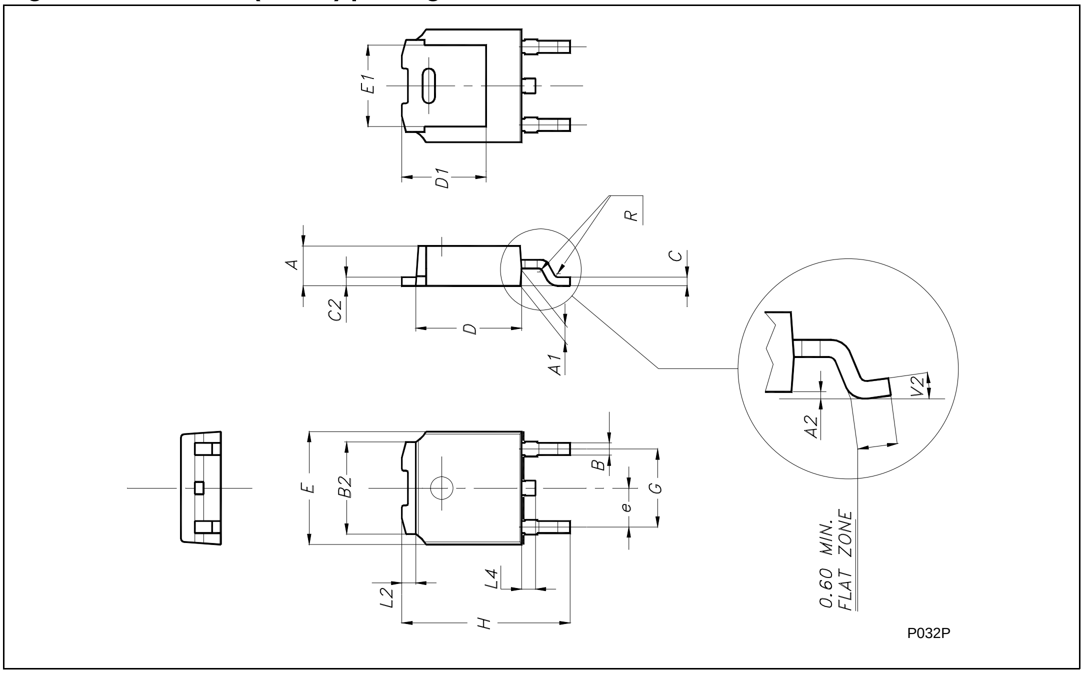
Table 6. TO-252 (DPAK) mechanical data

Symbol	millimeters		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
B	0.64		0.90
B2	5.20		5.40
C	0.45		0.60
C2	0.48		0.60
D	6.00		6.20
D1		5.1	
E	6.40		6.60
E1		4.7	
e		2.28	
G	4.40		4.60
H	9.35		10.10

Table 6. TO-252 (DPAK) mechanical data (continued)

Symbol	millimeters		
	Min.	Typ.	Max.
L2		0.8	
L4	0.60		1.00
R		0.2	
V2	0°	8°	
Package Weight	Gr. 0.29		

Figure 33. TO-252 (DPAK) package dimensions



4.4 SOT-223 mechanical data

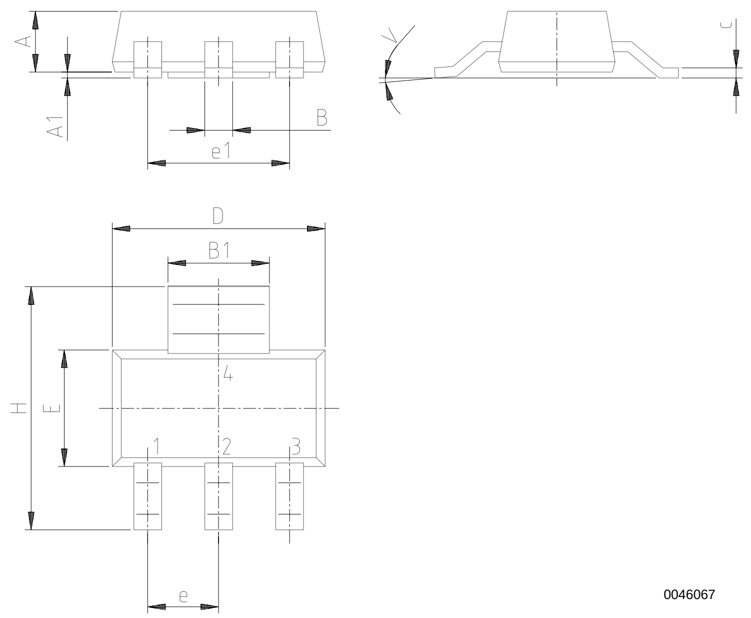
Table 7. SOT-223 mechanical data

Symbol	millimeters		
	Min.	Typ.	Max.
A			1.8
B	0.6	0.7	0.85
B1	2.9	3	3.15
c	0.24	0.26	0.35
D	6.3	6.5	6.7
e		2.3	

Table 7. SOT-223 mechanical data (continued)

Symbol	millimeters		
	Min.	Typ.	Max.
e1		4.6	
E	3.3	3.5	3.7
H	6.7	7	7.3
V		10 (max)	
A1	0.02		0.1

Figure 34. SOT-223 package dimensions



4.5 SO-8 mechanical data

Table 8. SO-8 mechanical data

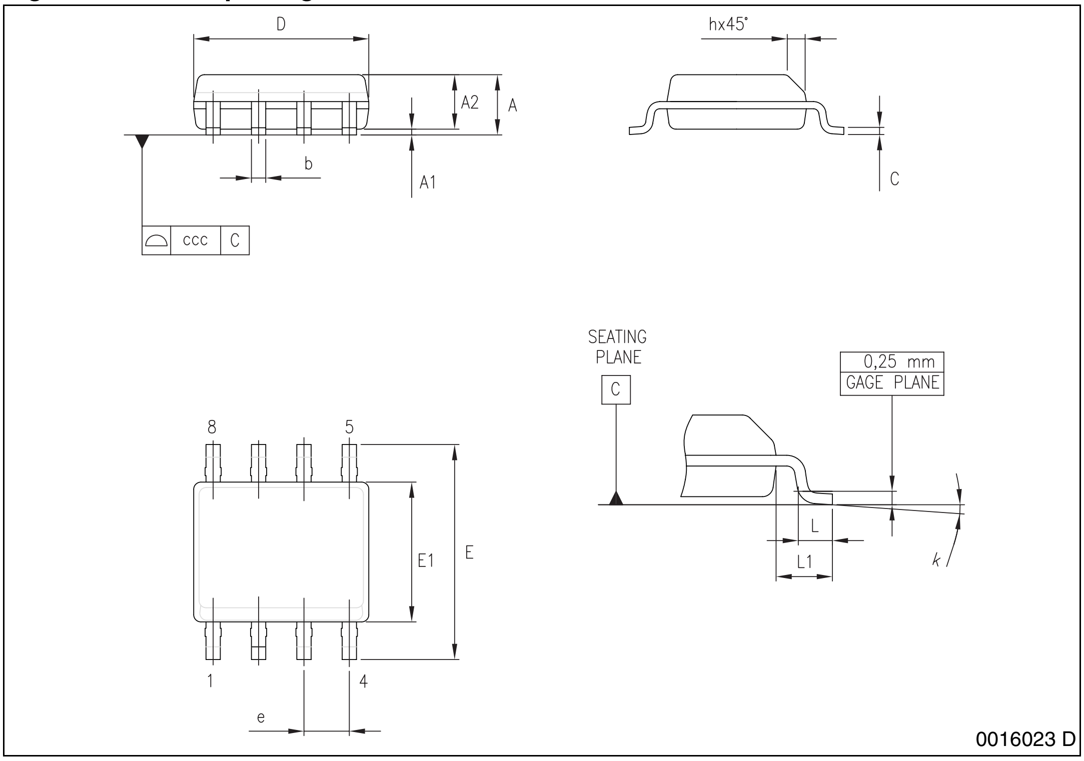
Symbol	millimeters		
	Min	Typ	Max
A			1.75
a1	0.1		0.25
a2			1.65
a3	0.65		0.85
b	0.35		0.48
A			1.75
A1	0.10		0.25

Table 8. SO-8 mechanical data (continued)

Symbol	millimeters		
	Min	Typ	Max
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D(1)	4.80	4.90	5.00
E	5.80	6.00	6.20
E1(2)	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

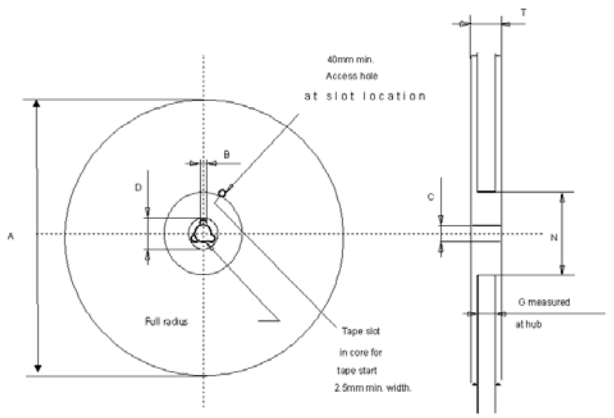
1. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm in total (both side).
2. Dimension “E1” does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25 mm per side.

Figure 35. SO-8 package dimensions



4.6 SOT-223 packing information

Figure 36. SOT-223 tape and reel shipment (suffix “TR”)



REEL DIMENSIONS

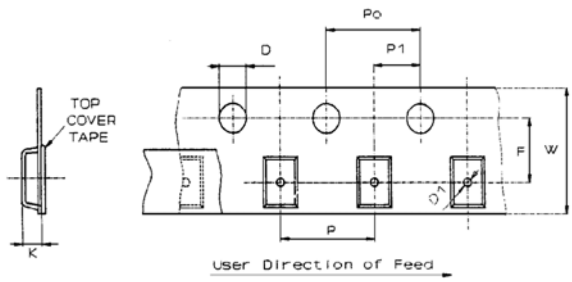
Base Q.ty	1000
Bulk Q.ty	1000
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

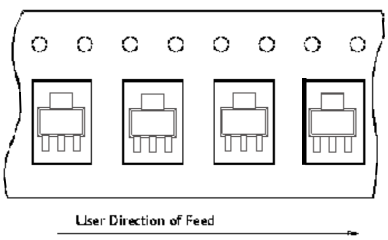
TAPE DIMENSIONS

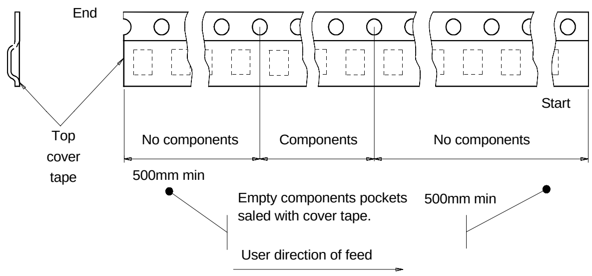
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

Tape width	**W**	12
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	8
Hole Diameter	**D (± 0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	5.5
Compartment Depth	**K (max)**	4.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.

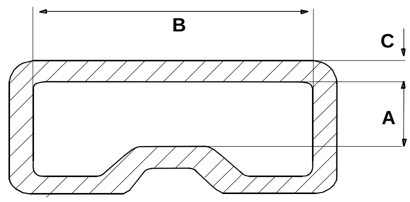






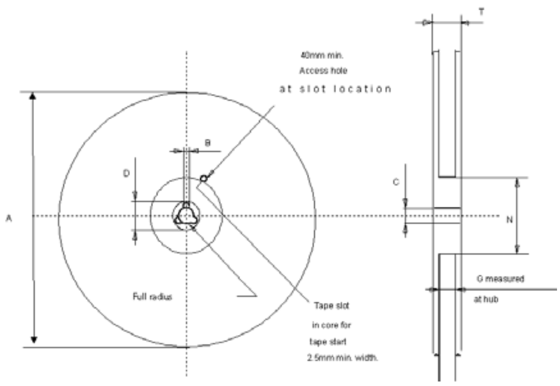
4.7 SO-8 packing information

Figure 37. SO-8 tube shipment (no suffix)



Base Q.ty	100
Bulk Q.ty	2000
Tube length (± 0.5)	532
A	3.2
B	6
C (± 0.1)	0.6

Figure 38. SO-8 tape and reel shipment (suffix “TR”)



REEL DIMENSIONS

Base Q.ty	2500
Bulk Q.ty	2500
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

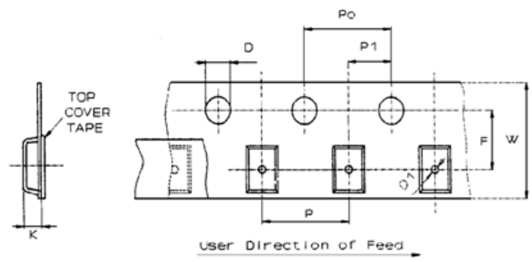
All dimensions are in mm.

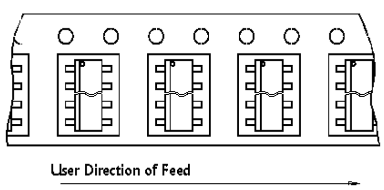
TAPE DIMENSIONS

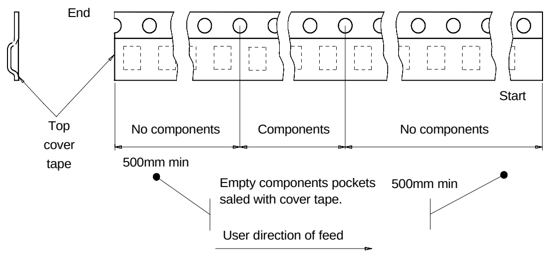
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

Tape width	**W**	12
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	8
Hole Diameter	**D (± 0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	5.5
Compartment Depth	**K (max)**	4.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.

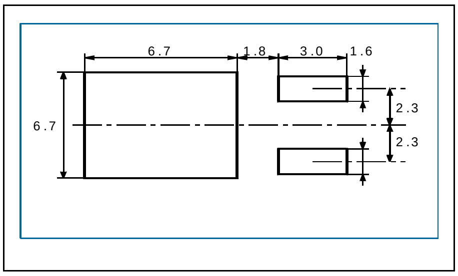


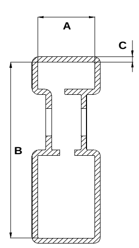




4.8 DPAK packing information

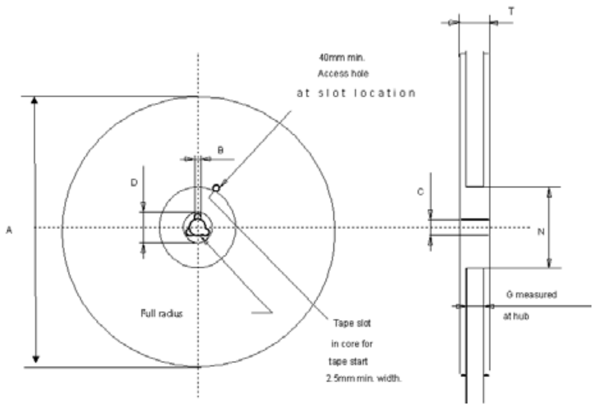
Figure 39. DPAK footprint and tube shipment (no suffix)





Base Q.ty	75
Bulk Q.ty	3000
Tube length (± 0.5)	532
A	6
B	21.3
C (± 0.1)	0.6

Figure 40. DPAK tape and reel shipment (suffix “TR”)



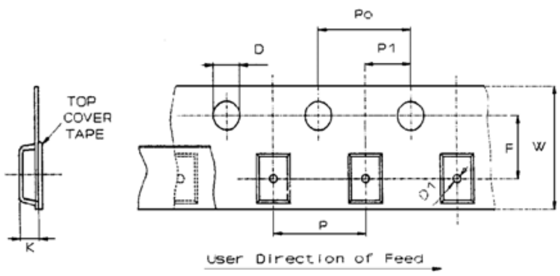
REEL DIMENSIONS

Base Q.ty	2500
Bulk Q.ty	2500
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	16.4
N (min)	60
T (max)	22.4

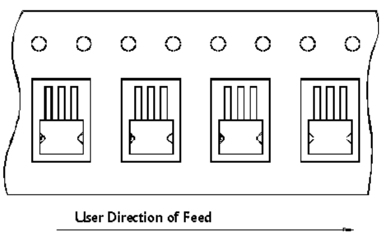
TAPE DIMENSIONS

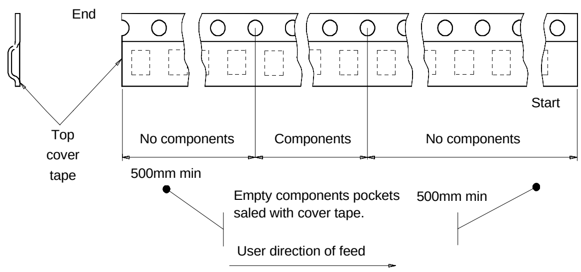
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

Tape width	**W**	16
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	8
Hole Diameter	**D (± 0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	7.5
Compartment Depth	**K (max)**	6.5
Hole Spacing	**P1 (± 0.1)**	2



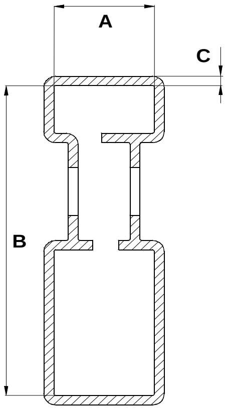
All dimensions are in mm.





4.9 IPAK packing information

Figure 41. IPAK tube shipment (no suffix)



Base Q.ty	75
Bulk Q.ty	3000
Tube length (± 0.5)	532
A	6
B	21.3
C (± 0.1)	0.6

All dimensions are in mm.

5 Revision history

Table 9. Document revision history

Date	Revision	Changes
01-Feb-2003	1	Initial Release
27-Apr-2009	2	Added *Table 1: Device summary on page 1* Updated *Table 4: Package and packing information on page 16*
05-Apr-2011	3	*Table 2: Absolute maximum ratings*: – $R_{IN\ MIN}$: changed unit from W to Ω Inserted *Section 4.1: ECOPACK®*